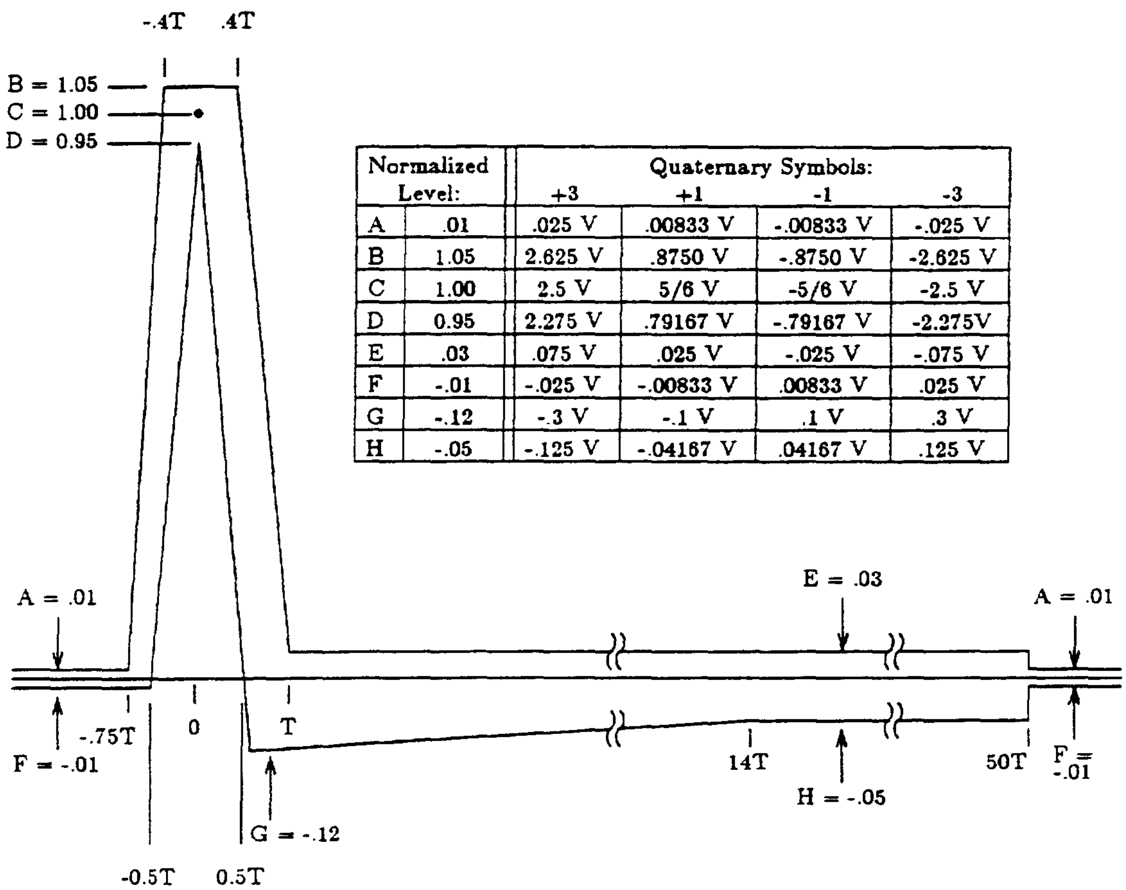
Time →

Data	B_1				B_2				D
Bit Pairs	$b_{11}b_{12}$	$b_{13}b_{14}$	$b_{15}b_{16}$	$b_{17}b_{18}$	$b_{21}b_{22}$	$b_{23}b_{24}$	$b_{25}b_{26}$	$b_{27}b_{28}$	d_1d_2
Quat # (relative)	q_1	q_2	q_3	q_4	q_5	q_6	q_7	q_8	q_9
# Bits	8				8				2
# Quats	4				4				1

Where:
b_{11} = first bit of B_1 octet as received at the S/T interface
b_{18} = last bit of B_1 octet as received at the S/T interface
b_{21} = first bit of B_2 octet as received at the S/T interface
b_{28} = last bit of B_2 octet as received at the S/T interface
d_1d_2 = consecutive D-channel bits
(d_1 is first bit of pair as received at the S/T interface)
q_i = ith quat relative to start of given 18-bit 2B+D data field

NOTE: There are 12 2B+D 18-bit fields per 1.5 msec basic frame.

Figure 5-1
2B1Q Encoding of 2B+D Bit Fields



Normalized Level:		Quaternary Symbols: +3	+1	-1	-3
A	.01	.025 V	.00833 V	-.00833 V	-.025 V
B	1.05	2.625 V	.8750 V	-.8750 V	-2.625 V
C	1.00	2.5 V	5/6 V	-5/6 V	-2.5 V
D	0.95	2.275 V	.79167 V	-.79167 V	-2.275V
E	.03	.075 V	.025 V	-.025 V	-.075 V
F	-.01	-.025 V	-.00833 V	.00833 V	.025 V
G	-.12	-.3 V	-.1 V	.1 V	.3 V
H	-.05	-.125 V	-.04167 V	.04167 V	.125 V

Figure 5-2
Normalized Pulse from NT or LT Transmitter

NOTE: Compliance of transmitted pulses within boundaries of the pulse mask is not sufficient to assure compliance with the power spectral density requirement and the absolute power requirement. Compliance with the requirements in 5.2.2.1 and 5.2.2.2 is also required.

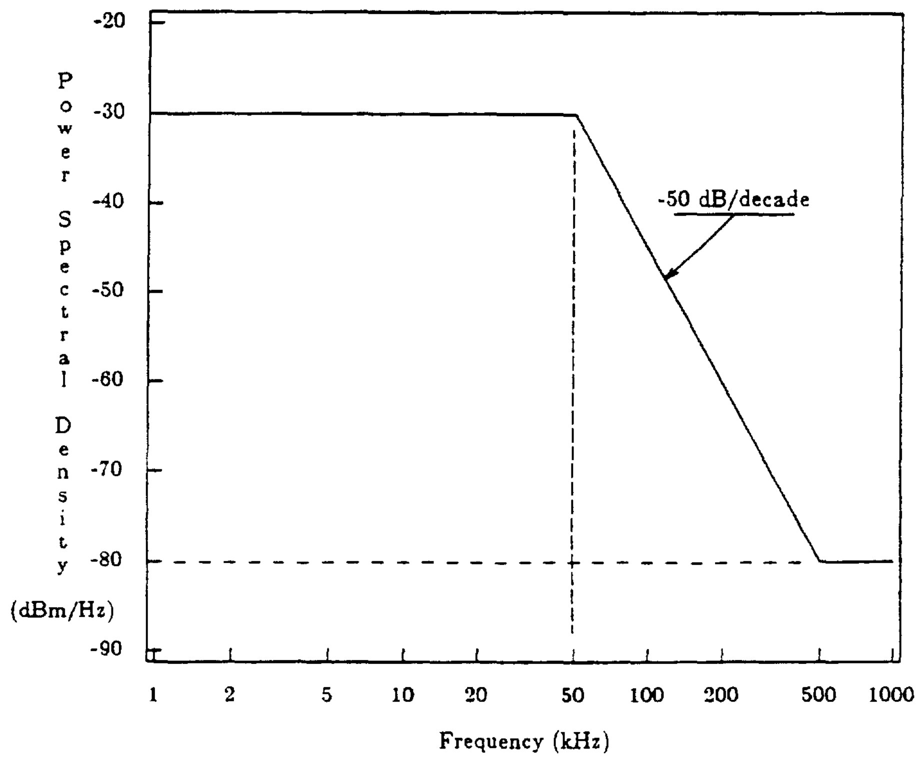


Figure 5-3
Upper Bound of Power Spectral Density of Signal from NT or LT Transmitter

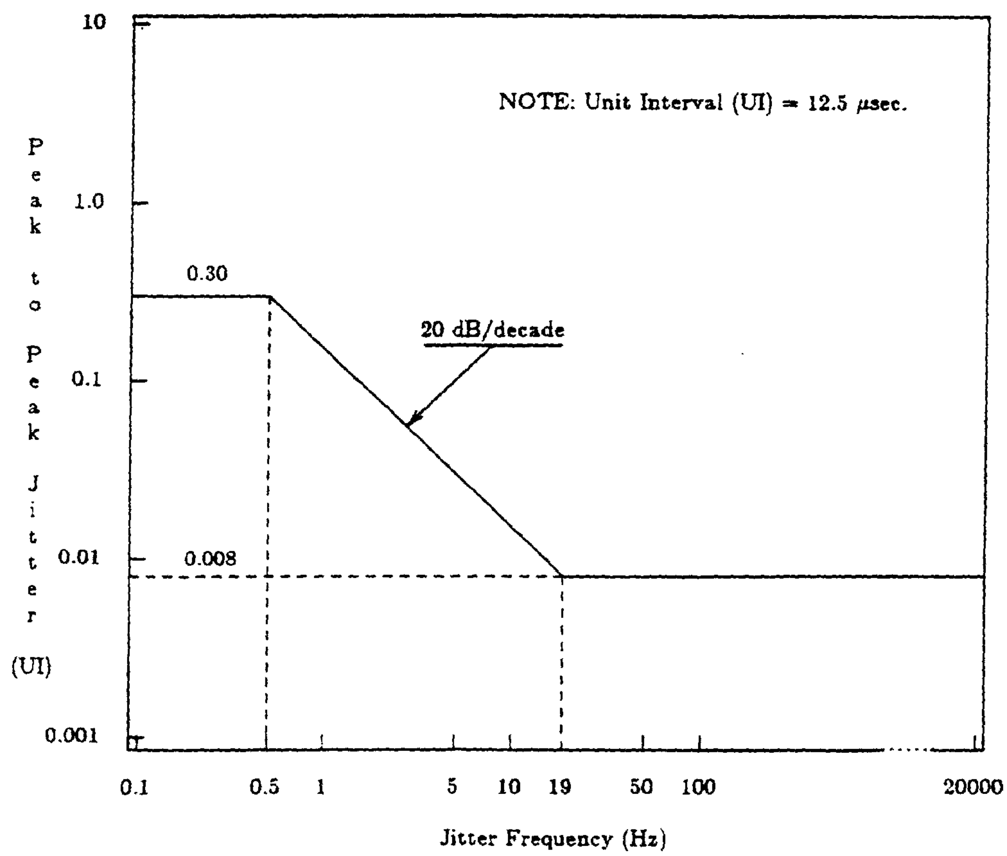


Figure 5-4
Range of Permissible Sinusoidal Jitter, Signal Originating from LT

	← 1.5 milliseconds →		
FRAME	SW/ISW	12 × (2B+D)	M

Function	Sync Word	2B+D	Overhead
# Quats	9	108	3
Quat Positions	1-9	10-117	118-120
# Bits	18	216	6
Bit Positions	1-18	19-234	235-240

Frames in the NT-to-LT direction are offset from frames in the LT-to-NT direction by 60 ± 2 quats

Symbols & Abbreviations:

quat	= quaternary symbol = 1 baud
− 3, − 1, + 1, + 3	= symbol names
2B+D	= Customer data channels B_1, B_2 and D
SW	= Synchronization Word (9-Symbol Code)
	= +3 +3 −3 −3 −3 +3 −3 +3 +3
ISW	= Inverted (or complementary) Sync Word
	= −3 −3 +3 +3 +3 −3 +3 −3 −3
M	= M-Channel Bits, M_1-M_6

Figure 5-5
ISDN Basic Access 2B1Q DSL 1.5 Millisecond Basic Frame

		FRAMING	2B+D	Overhead Bits (M_1-M_6)					
	Quat Positions	1-9	10-117	118s	118m	119s	119m	120s	120m
	Bit Positions	1-18	19-234	235	236	237	238	239	240
Superframe #	Basic Frame #	Sync Word	2B+D	M_1	M_2	M_3	M_4	M_5	M_6
A	1	ISW	2B+D	eoc_{a1}	eoc_{a2}	eoc_{a3}	act	1	1
	2	SW	2B+D	eoc_{dm}	eoc_{i1}	eoc_{i2}	dea	1	febe
	3	SW	2B+D	eoc_{i3}	eoc_{i4}	eoc_{i5}	1	crc_1	crc_2
	4	SW	2B+D	eoc_{i6}	eoc_{i7}	eoc_{i8}	1	crc_3	crc_4
	5	SW	2B+D	eoc_{a1}	eoc_{a2}	eoc_{a3}	1	crc_5	crc_6
	6	SW	2B+D	eoc_{dm}	eoc_{i1}	eoc_{i2}	1	crc_7	crc_8
	7	SW	2B+D	eoc_{i3}	eoc_{i4}	eoc_{i5}	uoa	crc_9	crc_{10}
	8	SW	2B+D	eoc_{i6}	eoc_{i7}	eoc_{i8}	aib	crc_{11}	crc_{12}
B, C, ...									

(*a*) *LT* → *NT*

		FRAMING	2B+D	Overhead Bits (M_1-M_6)					
	Quat Positions	1-9	10-117	118s	118m	119s	119m	120s	120m
	Bit Positions	1-18	19-234	235	236	237	238	239	240
Superframe #	Basic Frame #	Sync Word	2B+D	M_1	M_2	M_3	M_4	M_5	M_6
1	1	ISW	2B+D	eoc_{a1}	eoc_{a2}	eoc_{a3}	act	1	1
	2	SW	2B+D	eoc_{dm}	eoc_{i1}	eoc_{i2}	ps_1	1	febe
	3	SW	2B+D	eoc_{i3}	eoc_{i4}	eoc_{i5}	ps_2	crc_1	crc_2
	4	SW	2B+D	eoc_{i6}	eoc_{i7}	eoc_{i8}	ntm	crc_3	crc_4
	5	SW	2B+D	eoc_{a1}	eoc_{a2}	eoc_{a3}	cso	crc_5	crc_6
	6	SW	2B+D	eoc_{dm}	eoc_{i1}	eoc_{i2}	1	crc_7	crc_8
	7	SW	2B+D	eoc_{i3}	eoc_{i4}	eoc_{i5}	sai	crc_9	crc_{10}
	8	SW	2B+D	eoc_{i6}	eoc_{i7}	eoc_{i8}	1^*	crc_{11}	crc_{12}
2, 3, ...									

(*b*) *NT* → *LT*

NOTE: 8 × 1.5 ms Basic Frames → 12 ms Superframe.
NT-to-LT superframe delay offset from LT-to-NT superframe by 60±2 quats (about 0.75 ms).
All bits other than the Sync Word are scrambled.

Symbols & Abbreviations:

act = start-up bit (set = 1 during start-up)
aib = alarm indication bit (set = 0 to indicate interruption)
crc = cyclic redundancy check: covers 2B+D & M_4
  1 = most significant bit
  2 = next most significant bit
  etc.
cso = cold-start-only bit (set = 1 to indicate cold-start-only)
dea = turn-off bit (set = 0 to announce turn-off)
eoc = embedded operations channel
  a = address bit
  dm = data/message indicator (0 = data, 1 = message)
  i = information (data or message)
febe = far end block error bit (set = 0 for errored superframe)
ntm = NT in test mode bit (set = 0 to indicate test mode)
ps_1, ps_2 = power status bits (set = 0 to indicate power problems)
quat = pair of bits forming quaternary symbol
  s = sign bit (first in quat)
  m = magnitude bit (second in quat)
sai = S-activation-indic. bit (optional, set = 1 for S/T activity)
uoa = U-only-activation bit (optional, set = 1 to activate S/T)
"1" = reserved bit for future standard, (set = 1)
"1^*" = network indicator bit (reserved for network use)
2B+D = user data, bits 19-234 in frame
M = M-channel, bits 235-240 in frame
SW/ISW = synchronization word/inverted synchronization word, bits 1-18 in frame

Figure 5-6
2B1Q Superframe Technique and Overhead Bit Assignments

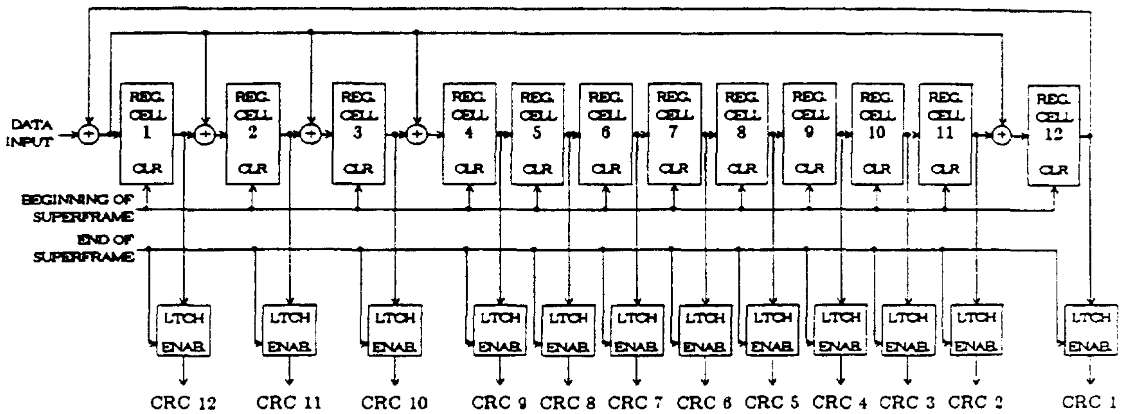
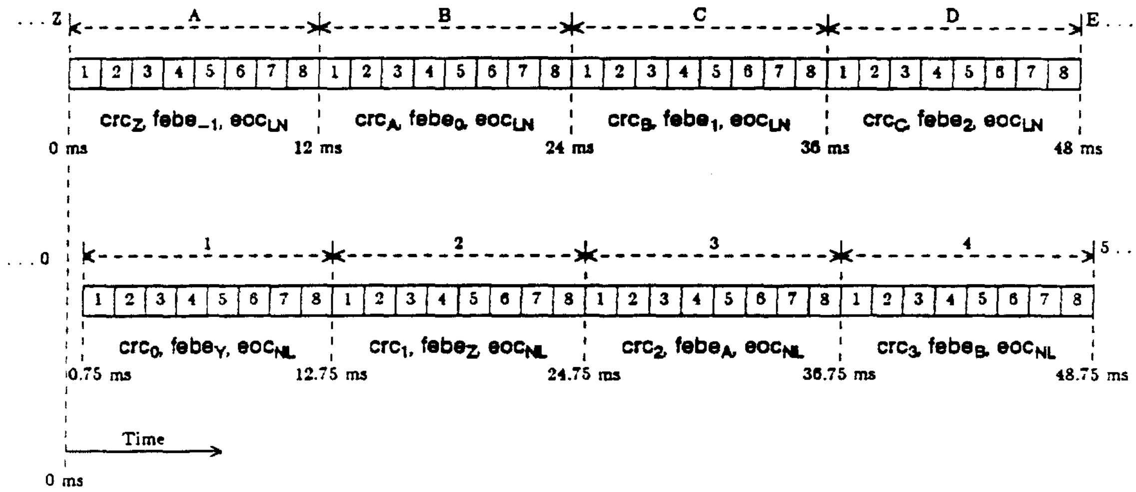


Figure 5-7
CRC-12 Generator



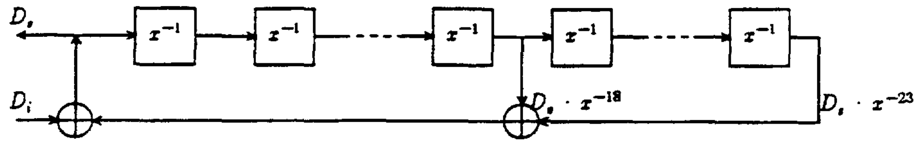
Where:
..., Y, Z, A, B, C, ... = LT-to-NT Superframes
..., -1, 0, 1, 2, 3, ... = NT-to-LT Superframes

$\boxed{i}$ = ith 1.5 ms Basic Frame in given Superframe

crc$_\gamma$ = Cyclic Redundancy Check Code for Superframe γ
febe$_\delta$ = Far End Block Error Bit for Superframe δ
eoc$_{ij}$ = Embedded Operations Channel
ij = LN = LT-to-NT direction
= NL = NT-to-LT direction

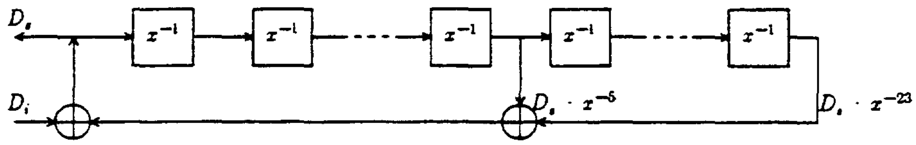
Figure 5-8
DSL Framing and Overhead Function Temporal Relationships

NT Transmit Scrambler (NT to LT) :



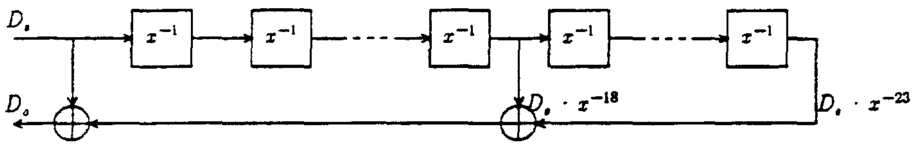
$$D_s = D_i \oplus D_s \cdot z^{-18} \oplus D_s \cdot z^{-23}$$

LT Transmit Scrambler (LT to NT) :



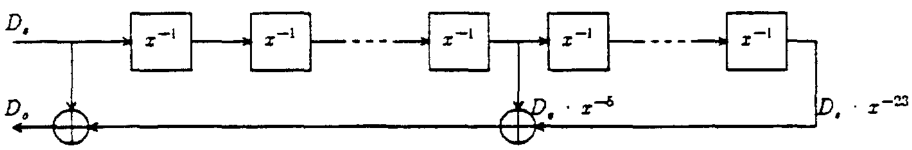
$$D_s = D_i \oplus D_s \cdot z^{-5} \oplus D_s \cdot z^{-23}$$

LT Receive Descrambler (NT to LT) :



$$D_o = D_s \cdot (1 \oplus z^{-18} \oplus z^{-23})$$

NT Receive Descrambler (LT to NT) :



$$D_o = D_s \cdot (1 \oplus z^{-5} \oplus z^{-23})$$

Figure 5-9
Scrambler and Descrambler

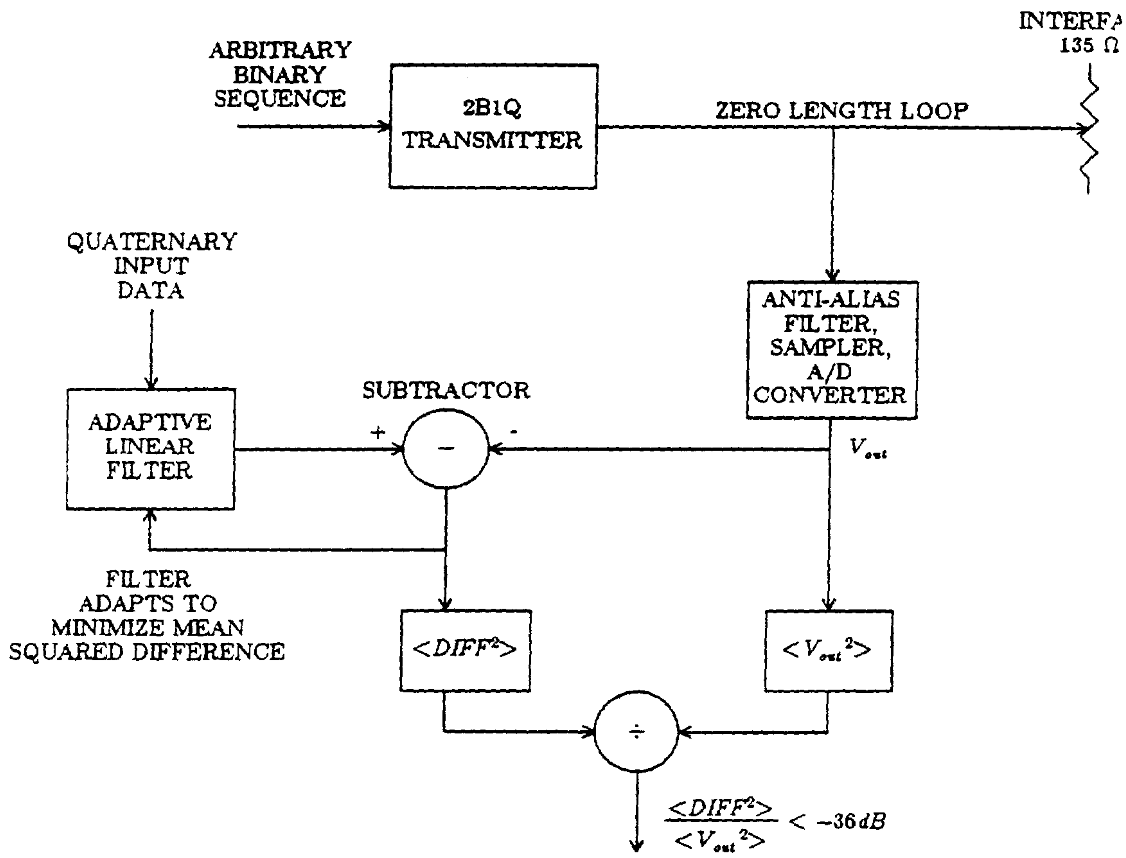


Figure 5-10
Measurement of DSL Transmitter Linearity

Signal	Synch Word (SW)	Super-frame (ISW)	2B+D	M	Start	Stop	Time (Frames)
TN	±3§	±3§	±3§	±3§	†	†	6
SN1	Present	Absent	1	1	T1	T2	-
SN2	Present	Absent	1	1	T5	T6	-
SN3	Present	Present	Normal+	Normal	T6	*	-
TL	±3§	±3§	±3§	±3§	†	†	2
SL1	Present	Absent	1	1	T3	T4	-
SL2	Present	Present	0	Normal	T4	T7	-
SL3	Present	Present	Normal+	Normal	T7	*	-

Symbols and Abbreviations:

§	- Tones have alternating pattern of four +3s followed by four -3s, and no SW.
†	- See Figure 5-12 and text of 5.10 for start and/or stop time of this signal.
TN, TL	- Tones produced by NT or LT, respectively (See 5.10).
SNx, SLx	- Pulse patterns produced by NT or LT, respectively.
Tx	- Notation refers to transition instants defined in Figure 5-12.
Absent	- Under Superframe this notation means that only SW is transmitted, not ISW.
Normal	- Normal means that the M bits are transmitted onto the 2-wire line as required during normal operation; e.g., valid crc bits, eoc bits, and indicator bits are transmitted
Normal+	- Except to perform a loopback, B- and D-channel bits shall remain in the previous state (i.e., the B- and D-channel bits shall remain set to 1 in SN3 and set to and 0 in SL3) until transparency is achieved as described in 5.10.7.6.
*	- Signals SN3 and SL3 continue indefinitely (or until turn-off).

Figure 5-11
Definitions of Signals During Start-Up

APPENDIX B
CHARACTERISTICS OF TELEPHONE LOOP PLANT

B.1. Introduction

The 1983 Loop Survey was a nationwide study to characterize the loop plant for the Bell Operating Companies and to provide information about several physical and topographical characteristics related to the subscriber loop. The data provides information necessary to conduct feasibility and simulation studies of transmission characteristics over the existing wire pairs at different baud rates. The data shows that the real loop plant is far from the ideal in which uniform gauge wires run from the central office to the subscriber. Any design of a bidirectional data transmission facility must accommodate the wide disparity of cable compositions, bridged-tap configurations and highly variable impedances of the loop. Science and Technology report ST-TSY-00041 presents a full report on the 1983 loop survey.

This Appendix presents a brief description of both physical and transmission characteristics of the loops. The information is in graphical and tabular form, concentrating on those characteristics relevant to Basic Access transmission rates.

Section B.2 describes briefly the physical characteristics of the loop and Section B.3 describes the transmission characteristics derived by calculations from the loop make-ups. Section B.4 contains a discussion of the statistics in Sections B.2 and B.3.

B.2. Physical Characteristics

The 1983 Loop Survey consisted of a stratified random sample of 2290 working pairs from the participating Bell Operating Companies. About 23.7% of the sampled pairs are loaded, and thus unfit for ISDN access. This removes 543 loops from the survey. Another 227 loop configurations either did not have a sufficiently accurate description to allow analysis of the proposed ISDN services, or were non-loaded but longer than 18 kFt, or were loops that have non-standard cable make-up thus further reducing the subset used for characterizing ISDN transmission. The remaining subset consists of 1520 working pairs, which is about 66% of the total sample.

Figure B-1 is the distribution of the working length of all 2290 sampled pairs. The average length of a sampled working pair is 10787 feet; the standard error in the estimation of this mean is 188 feet. The figure shows that about 80% of the sampled pairs have working length less than or equal to 15000 feet

Figure B-2 is the distribution of the working length of the subset consisting of 1520 non-loaded pairs. The average length of a non-loaded sampled working pair is 7535 feet, the standard error in the estimation of this mean is 116 feet. The figure shows that about 90% of the non-loaded loops have working length less than or equal to 15000 feet.

B.3. Transmission Characteristics

This section characterizes loop transmission in terms of attenuation as a function of frequency. The attenuation loss of loops in the subset has been calculated at six different frequencies: 40, 60, 80, 120, 160 and 200 kHz Attenuation loss is the same as insertion loss if the impedance perfectly matched at both ends of the loop. Figure B-3 shows the distribution of loss in dB at each frequency. The loss determines the amount of compensation necessary from the equalizers; it also provides an estimate of the percentage of loops in the population that can b

served by a given equalizer design.
The following table shows the statistics of the data plotted in Figure B-3.

LOOP LOSS FOR ISDN FREQUENCIES

Freq kHz	Min dB	Max dB	Mean dB	SDM dB
40	.28	45.6	18.5	.26
60	.30	51.3	20.6	.29
80	.33	56.0	22.2	.31
120	.37	63.6	24.9	.35
160	.41	74.5	27.2	.38
200	.45	79.7	29.3	.41

B.4. Discussion

The statistic *SDM*, used in Figures B-1 and B-2 and the table in Section B.3, is the standard error in the estimation of the sample mean. To calculate a 90% confidence interval for the sample mean of the working length (Figure B-1) 10787 feet, use the confidence coefficient for the 90% level, 1.645; multiply by 188, the *SDM* for the working length, obtaining 309, and the resulting 90% confidence interval for the mean of the working length is 10787 $\pm$ 309 feet . This means that with probability .9, the mean length of a working pair lies in this interval.

FIGURE B-1

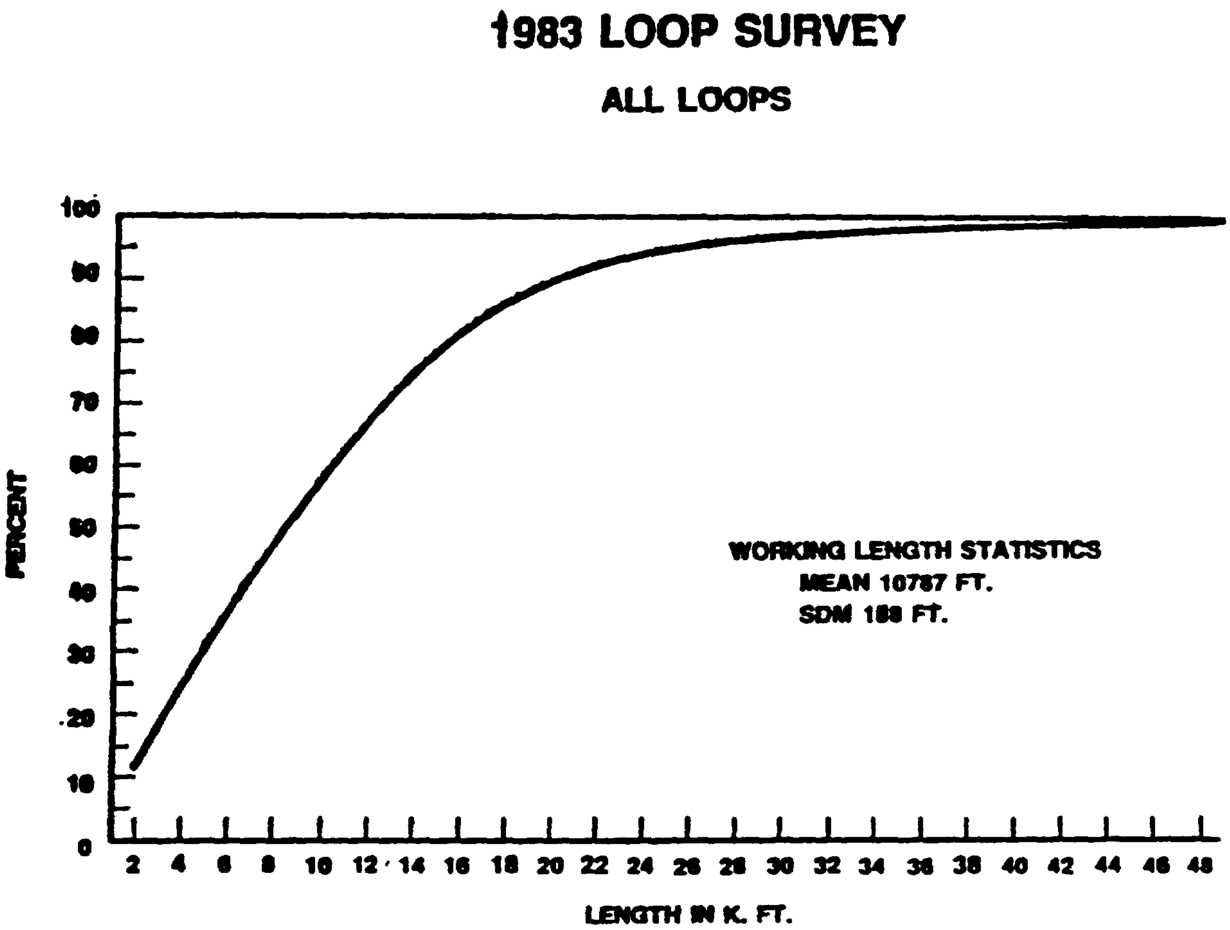

1983 LOOP SURVEY
ALL LOOPS
100
90
80
70
60
50
40
30
20
10
0
PERCENT
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
LENGTH IN K. FT.
WORKING LENGTH STATISTICS
MEAN 10787 FT.
SDM 188 FT.

FIGURE B-2

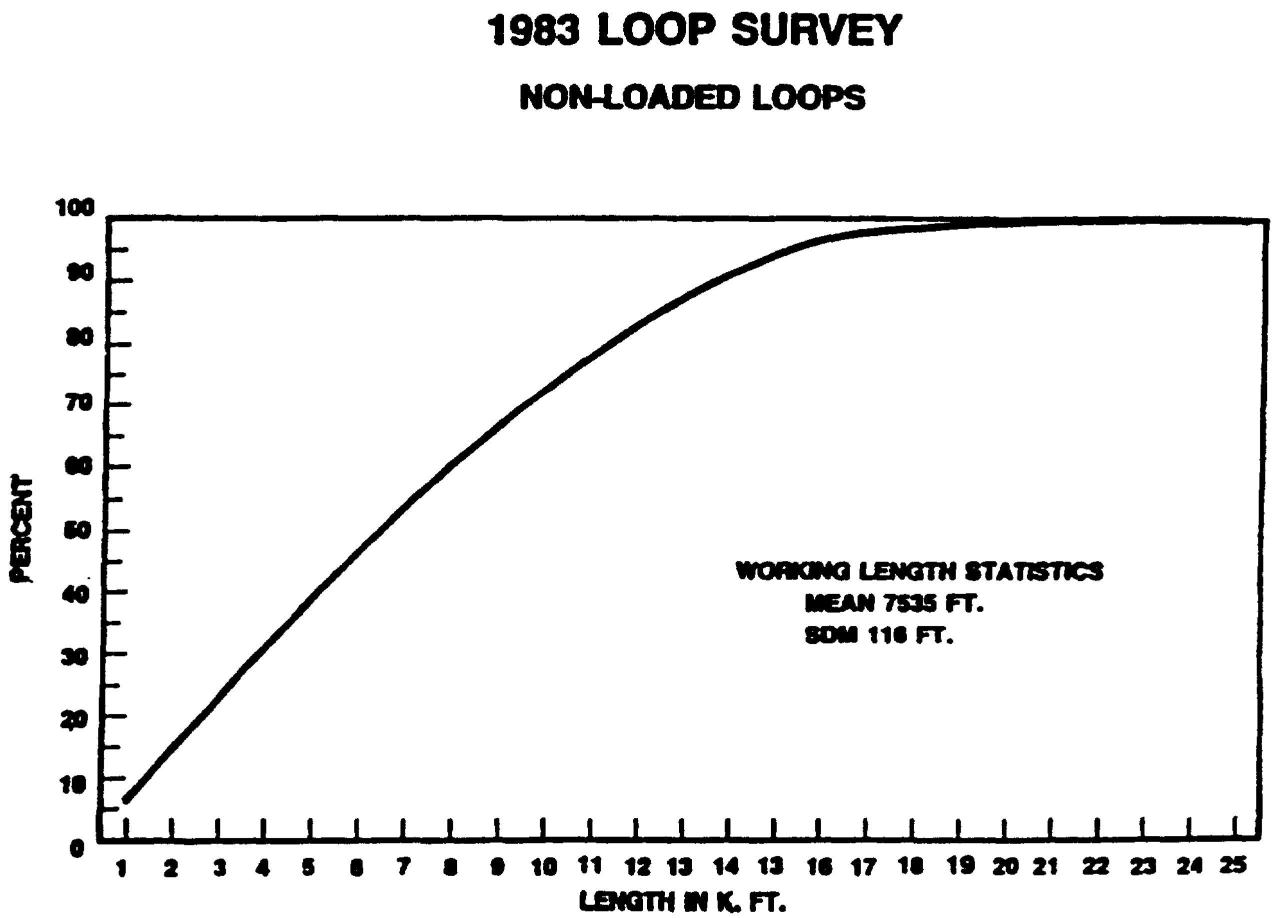
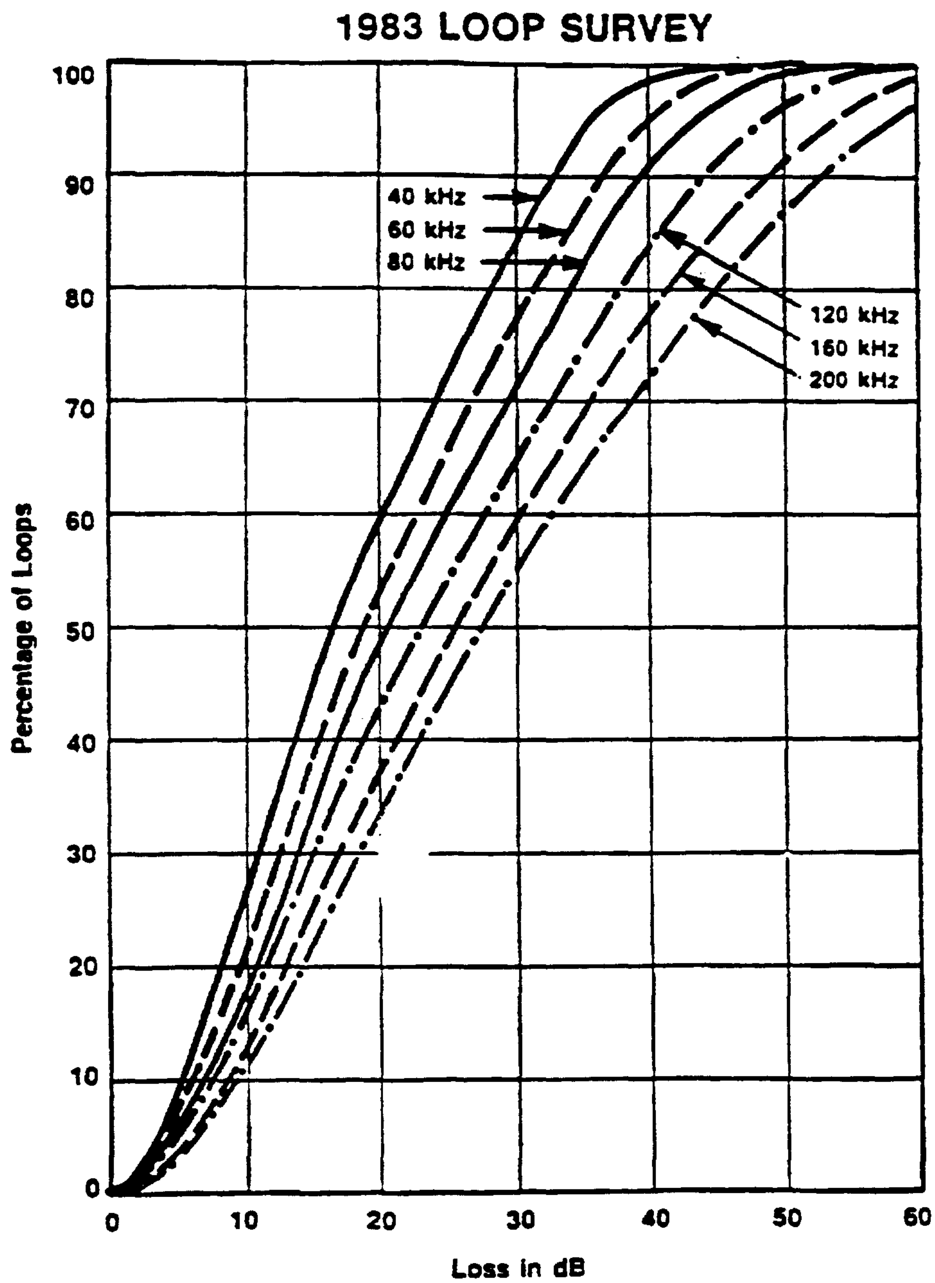

1983 LOOP SURVEY
NON-LOADED LOOPS
PERCENT
0
10
20
30
40
50
60
70
80
90
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
LENGTH IN K. FT.
WORKING LENGTH STATISTICS
MEAN 7535 FT.
SDM 116 FT.

FIGURE B-3



LOSS AT 40, 60, 80, 120, 160, 200 kHz
Loops Loss Distribution Curves